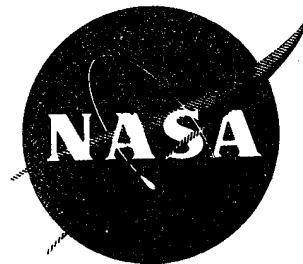


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NASA CR 72099  
TRW 06378-6007-R001



DESIGN GUIDE  
FOR USE OF POLYURETHANE FOAM  
AS AN ENCAPSULANT FOR HIGH VOLTAGE DEVICES

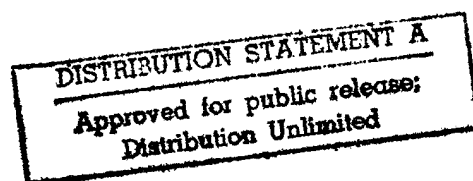
by

C. J. Holzbauer

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Contract NAS 3-8905



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TRW SYSTEMS GROUP, INC.  
Redondo Beach, California

UNLIMITED

DEPARTMENT OF DEFENSE  
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April 1967

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## 1. INTRODUCTION

A recent program<sup>1</sup> has investigated the foam-in-place polyurethanes as encapsulants for high voltage devices that are used in the space environment. Results from this study indicate that these materials are usable for this application. Based on this study, a process for the application of these polyurethanes has been prepared<sup>2</sup>. The guide lines found in this document for package design are also based on the results obtained from the referenced study and generally accepted practice.

## 2. APPLICABLE PROCESSES

Polyurethane foams can be processed by a variety of means, varying from simple hand mixing to special automatic mixing and dispensing machinery. A process for foaming electrical and electronic modules and assemblies is documented in NASA Report CR 72098. This process provides a relatively simple means of encapsulating these devices in the foam materials described in this design guide.

## 3. PREFERRED MATERIALS

The preferred foam-in-place materials are:

CPR 23 Series

Manufactured by the CPR Division,  
The Upjohn Company  
555 Alaska Avenue  
Torrance, California 90503

Stafoam AA 600  
Series

Manufactured by the Polytron Department,  
Olin-Mathieson Chemical Corporation  
661 South Tenth Street  
Richmond, California 94804

3.1 Physical Properties. Some of the important physical properties and processing characteristics of the preferred foam materials are presented in Table 1.

3.2 Mechanical Properties. Some of the important mechanical properties of the preferred foam materials are presented in Table 2. These values are derated to provide a margin of safety of 1.5.

3.3 Dynamic Properties. Some important dynamic properties of the preferred foam materials are presented in Tables 3 and 4.

1. Holzbauer, C. J. and Holbrook, R. J., "Foam-In-Place Materials for High Voltage Insulation in a Space Environment," NASA Report No. CR 72100, Apr 1967.
2. Holzbauer, C. J., Process Specification "Application of Foam-In-Place Polyurethane to High Voltage Devices," NASA Report No. CR 72098, April 1967.

3.4 Electrical Properties. Some of the important electrical properties of the preferred foam materials are presented in Table 5.

#### 4. DESIGN REQUIREMENTS

4.1 Tolerances. Because of material shrinkage characteristics during molding, exceptionally close tolerances should not be specified. Hole size and tolerances should likewise be loose to allow for molding them in place. The recommended tolerances for molded foam parts should be as specified in Table 6.

4.2 Holes. In general it is best to avoid the requirement for holes in molded foam parts. However, when they cannot be avoided, holes should be molded into the part to prevent breaking the skin of the foam surface. If it is necessary to drill a hole into the foam, the hole should be drilled oversize .020 to .040 inch in diameter and the cut surface should be sealed with a thermosetting plastic, such as an epoxy. Then the hole should be redrilled to size. Holes should be designed with as great a diameter as possible. For molded holes it is generally not practical to exceed the values shown in Table 7.

4.3 Draft. Generally for exterior surfaces of molded foam parts no draft allowance is required since the common molds are completely disassembled to remove the part. For molded wells and other recessed volumes, a draft of at least .010 inch per inch should be provided.

4.4 Inserts, Studs and Similar Hardware. In general, inserts, studs, and similar hardware should not be molded in foamed parts because of the relatively low strength of the foam. Recommended means for securing the foamed part to its support member are tie-down strap, foaming-in-place in a chassis, and adhesive bonding. Inserts and studs can be used by first securing them to a structural member and then bonding or foaming this structural member in place.

TABLE 1

## Physical Properties and Processing Characteristics

|   |                         | Foam Density (lbs/ft <sup>3</sup> ) |                 |                 |                       |                 |                 |
|---|-------------------------|-------------------------------------|-----------------|-----------------|-----------------------|-----------------|-----------------|
|   |                         | CPR 23 Series                       |                 |                 | Stafoam AA 600 Series |                 |                 |
|   |                         | 4                                   | 8               | 20              | 4                     | 8               | 20              |
| Blowing Agent                               |                         | CO <sub>2</sub>                     | CO <sub>2</sub> | CO <sub>2</sub> | CO <sub>2</sub>       | CO <sub>2</sub> | CO <sub>2</sub> |
| Maximum Service Temperature, (°F)           |                         | 250                                 | 250             | 250             | 250                   | 250             | 250             |
| Cure Temperature, (°F)                      |                         | 210                                 | 210             | 210             | 210                   | 210             | 210             |
| Exothermic Temperature, (°F)                |                         | 374                                 | 374             | 360             | 379                   | 392             | 401             |
| Moisture Absorption, (volume %)             |                         | 2                                   | 2               | 2               | 2                     | 2               | 2               |
| Effect of Thermal Aging<br>250 hrs. @ 257°F | Weight Change, (1%)     | -2                                  | -1.3            | -0.3            | -2                    | -1.4            | -0.2            |
|   | Dimensional Change, (%) | -0.3                                | -0.3            | -0.2            | -0.3                  | -0.4            | -0.6            |

TABLE 2

## Mechanical Properties

|                                 |  | Foam Density (lbs/ft <sup>3</sup> ) |        |        |                       |        |         |
|---------------------------------|--|-------------------------------------|--------|--------|-----------------------|--------|---------|
|                                 |  | CPR 23 Series                       |        |        | Stafoam AA 600 Series |        |         |
|                                 |  | 4                                   | 8      | 20     | 4                     | 8      | 20      |
| *Tensile Strength, psi          |  | 30                                  | 75     | 270    | 53                    | 145    | 600     |
| Compressive Strength, psi       |  | 35                                  | 140    | 390    | 32                    | 83     | 590     |
| Compressive Modulus<br>(actual) |  | 8,000                               | 26,000 | 70,000 | 17,000                | 40,000 | 140,000 |

\*Based on vendor data

TABLE 3

Dynamic Properties: Vibration Amplification

|                                     |               |    | 50  | 100 | 200 | 400 | 600 | 800 | 1000 | 1200 | 1500 | 2000 |
|-------------------------------------|---------------|----|-----|-----|-----|-----|-----|-----|------|------|------|------|
| Foam Density (lbs/ft <sup>3</sup> ) | CPR 23        | 4  | 1.2 | 1.2 | 1.2 | 1.4 | 2.1 | 6.5 | 6.5  | 1.8  | --   | --   |
|                                     |               | 8  | 1.0 | 1.0 | 1.0 | 1.0 | 1.3 | 1.7 | 3.0  | 10.0 | 4.5  | 2.0  |
|                                     |               | 20 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1 | 1.2 | 1.3  | 1.4  | 1.8  | 3.5  |
|                                     | Stafoam AA600 | 4  | 1.2 | 1.2 | 1.3 | 2.0 | 4.0 | 1.8 | --   | --   | --   | --   |
|                                     |               | 8  | 1.1 | 1.1 | 1.1 | 1.2 | 1.5 | 2.0 | 4.2  | 5.5  | 3.0  | 1.5  |
|                                     |               | 20 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.1  | 1.3  | 1.6  | 3.5  |

TABLE 4

Dynamic Properties: Transmissibility at Resonant Frequency

|                                     |               |    | Transmissibility at Resonant Frequency |
|-------------------------------------|---------------|----|--|
| Foam Density (lbs/ft <sup>3</sup> ) | CPR 23        | 4  | 45 @ 890 cps                           |
|                                     |               | 8  | 35 @ 1200 cps                          |
|                                     |               | 20 | 70 @ 2800 cps                          |
|                                     | Stafoam AA600 | 4  | 40 @ 580 cps                           |
|                                     |               | 8  | 55 @ 1170 cps                          |
|                                     |               | 20 | 70 @ 2600 cps                          |

TABLE 5  
Selected Electrical Properties

|  | Foam Density (lbs/ft <sup>3</sup> ) |       |       |                       |       |       |
|--|-------------------------------------|-------|-------|-----------------------|-------|-------|
|  | CPR 23 Series                       |       |       | Stafoam AA 600 Series |       |       |
|  | 4                                   | 8     | 20    | 4                     | 8     | 20    |
| Dielectric Strength, KVDC<br>(Electrodes polished, .250 inch<br>minimum spacing) | 5                                   | 5     | 5     | 5                     | 5     | 5     |
| Dielectric Constant, @ 60 cps  | 1.03                                | 1.05  | 1.08  | 1.02                  | 1.04  | 1.10  |
| Dissipation Factor, @ 60 cps   | 0.001                               | 0.002 | 0.002 | 0.001                 | 0.001 | 0.002 |

TABLE 6  
Recommended Tolerances for Foamed Parts

| Dimension (inches) | Tolerance ( $\pm$ inches) |
|--------------------|---------------------------|
| up to 1.000        | 0.007                     |
| 1.000 to 3.000     | 0.010                     |
| 3.000 to 5.000     | 0.015                     |

TABLE 7

Molded Foam Hole Dimensions  
(in inches)

| Hole Diameter | Maximum Blind<br>Hole Depth | Maximum Through<br>Hole Depth | Minimum<br>Edge Margin |
|---------------|-----------------------------|-------------------------------|------------------------|
| 0.063         | 0.063                       | 0.125                         | 0.150                  |
| 0.094         | 0.126                       | 0.250                         | 0.175                  |
| 0.125         | 0.188                       | 0.375                         | 0.220                  |
| 0.188         | 0.313                       | 0.625                         | 0.275                  |
| 0.250         | 0.438                       | 0.875                         | 0.350                  |